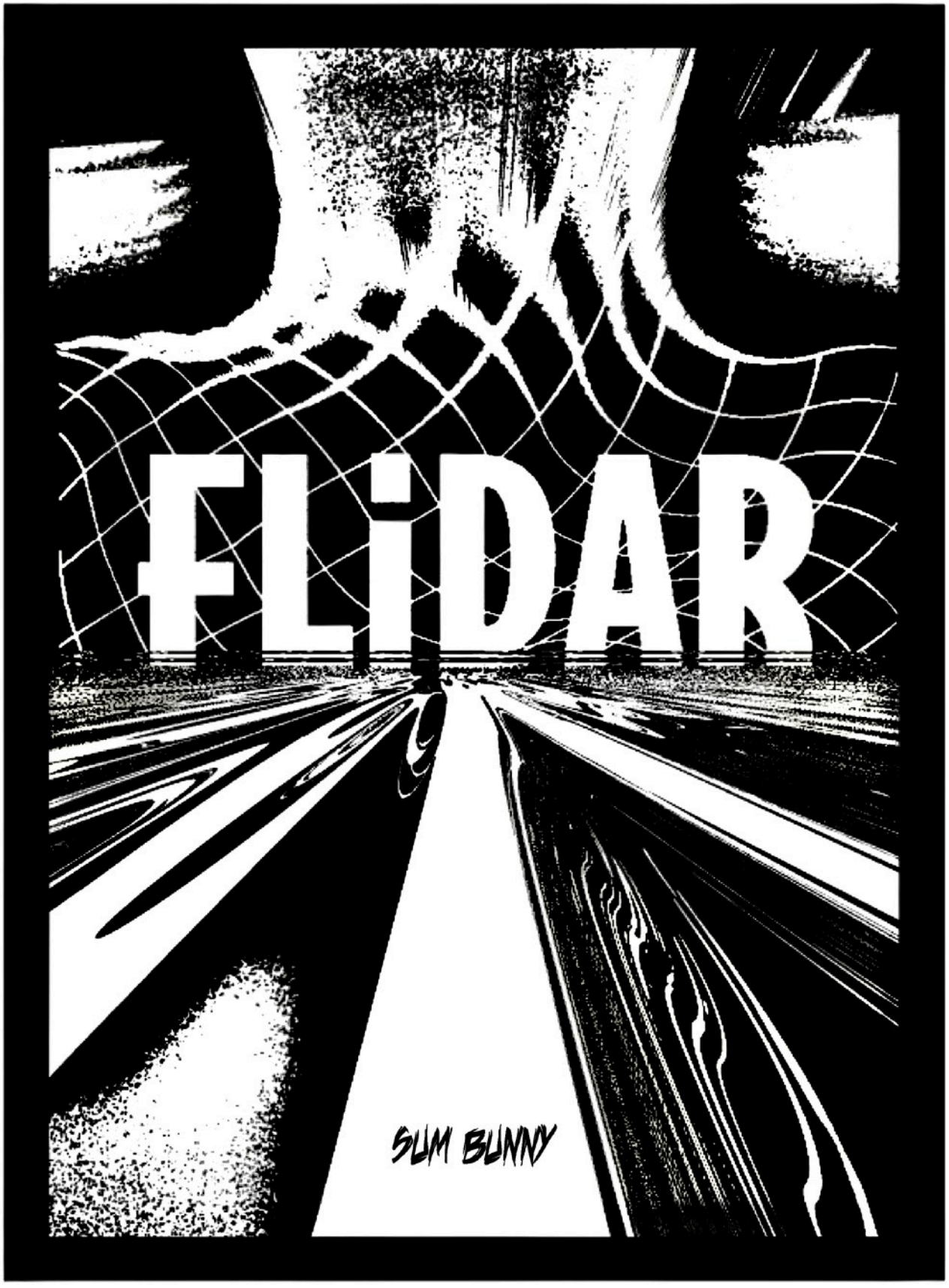
FLiDAR
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FLiDAR

THE ARCHAEOLOGY OF LIGHT

A Proposal for Fossil-Light Detection And Ranging

By Sum Bunny

Abstract We propose Fossil-LiDAR (FLiDAR), an experimental protocol to constrain stationary classical metric microstructure at terrestrial optical scales. Building on the Armature Ripple Theory (ART) framework, we posit that a scalar field φ coupled to curvature may leave a residual, static imprint on the local vacuum metric $g_{\mu\nu}$. Utilizing the Gordon optical metric formalism [1], we model this structure as a stochastic anisotropy in the effective refractive index of the vacuum. To distinguish this microscopic signal from macroscopic atmospheric turbulence, FLiDAR employs dual-aperture intensity interferometry (Hanbury Brown-Twiss effect) [2]. Drawing on cross-disciplinary precedents from noise-assisted inference and ambient noise seismic interferometry, we reframe the atmosphere not as a noise source, but as a requisite dynamic statistical converter. We present the theoretical scalar action, detail the mesopic biological precedent for this hybrid sensing architecture, outline the requisite signal-to-noise ratio (SNR) scaling regimes, and propose a hardware roadmap utilizing FPGA-based edge correlators. Even in the event of a null result, FLiDAR provides a novel experimental upper bound on stationary metric perturbations distinct from transient gravitational wave limits. This work is structured to produce value even under complete hypothesis failure, simultaneously generating high-fidelity noise intelligence for next-generation operational LiDAR.

I. The Shape of the Wind: The Optical Palimpsest

There is a moment in every LiDAR scan where the machine lies to you. You fire a laser pulse at a wall, expecting a sharp return, but receive a "dirty" waveform—a peak surrounded by a haze of statistical noise. Engineering filters discard this haze to map the wall.

FLiDAR is a proposal to stop throwing away the haze. In this framework, the optical path between the emitter and the target is a palimpsest. The atmosphere writes a loud, dynamic surface text (*scriptio superior*), but we posit that the Gordon metric preserves the *scriptio inferior*—a faint, stationary textural imprint of the vacuum itself, readable only through long-baseline statistical subtraction.

By shifting from Time-of-Flight (ToF) to Statistics-of-Flight, we analyze the higher-order coherence functions of the laser return to map not the obstacles in the room, but the medium they occupy. We aim to map the grain of spacetime itself.

II. The Physics: Optical Metric Equivalence

To rigorous physicists, the concept of a "refractive index of vacuum" sounds suspect. However, in General Relativity, it is a standard tool. As established by Gordon (1923), the propagation of electromagnetic waves in a curved spacetime metric $g_{\mu\nu}$ is mathematically equivalent to propagation through an anisotropic dielectric medium with an effective refractive index tensor n_{ij} [1].

The Disclaimer & Guardrail: The Gordon metric provides a formal mapping only; FLiDAR tests whether any stationary perturbation field exists whose optical effect can be parameterized in this language. All hypothesized structure is modeled purely as a classical, stationary effective refractive anisotropy parameterized phenomenologically; no claim is made about underlying quantum-gravitational degrees of freedom.

The Mechanism: FLiDAR does not assume metric microstructure exists. It posits that if any stationary perturbation field exists above a dimensionless amplitude ϵ, it will manifest as a modulation of the effective index δn_{eff}. We are detecting classical metric microstructure via its cumulative effect on photon propagation statistics.

III. The Theoretical Model: Scalar Action

To provide a mathematical scaffold and ground the parameter space without committing to a specific quantum gravity claim, we evaluate an effective action where a scalar field φ couples to the topological structure of spacetime [4]. The governing action is:

$$S=\int d^4x\sqrt{-g}\left[2M_{Pl}^2 R-\frac{1}{2} g_{\mu\nu}\nabla^\mu \varphi\nabla^\nu \varphi-V(\varphi)+f(\varphi)G\right]$$

where M_{Pl} is the reduced Planck mass, R is the Ricci scalar, $G\equiv R^2-4R_{\mu\nu}R^{\mu\nu}+R_{\mu\nu\rho\sigma}R^{\mu\nu\rho\sigma}$ is the Gauss-Bonnet invariant, $V(\varphi)$ is the scalar potential, and $f(\varphi)$ is the coupling function with dimensions of length squared.

This coupling introduces new curvature dynamics (as the coupled invariant is no longer purely topological), potentially leaving residual static perturbations in the weak-field limit. Existing astrophysical constraints bound this coupling depending heavily on the assumed function $f(\varphi)$ and local screening mechanisms; FLiDAR operates strictly in the ultralight regime of interest where macroscopic coherence lengths are possible, and screening behavior is model-dependent and treated parametrically. We probe the coupling strength by searching for coherence lengths $\lambda_c \sim \hbar/(m_\varphi c)$compatible with terrestrial baselines.

IV. Twilight Conversion & Noise-Assisted Inference

We cannot measure phase shifts directly; atmospheric turbulence creates phase variance orders of magnitude larger than any expected metric effect. We must rely on Intensity Interferometry.

HBT intensity interferometry accesses second-order coherence via intensity correlations; here we operate in a turbulence-thermalized regime where the observable is dominated by speckle-induced excess intensity correlations rather than intrinsic thermal emission. FLiDAR functions precisely because the atmosphere acts as a dynamic statistical converter: phase coherence is scrambled by refractive turbulence, transforming coherent illumination into pseudo-thermal light via evolving speckle.

Noise-Assisted Inference and the Transfer Function: This dynamic mixing simultaneously generates measurable intensity correlations. The atmosphere acts as a macroscopic instance of noise-assisted inference: the chaotic refractive noise is structurally required to elevate the sub-threshold stationary metric perturbation into the observable second-order intensity regime. The measurement statistic is nonlinear in intensity, and residual-detection SNR can be non-monotonic in speckle contrast.

The transfer function of the hypothetical metric microstructure does not merely renormalize path length or scintillation strength. Rather, it is hypothesized to imprint an anomalous, baseline-dependent spatial anisotropy in the degree of coherence (targeting theoretical residual contrasts on the order of 10−18) that deviates from the baseline-scaling predicted by Kolmogorov or von Kármán turbulence when propagated through a standard statistical optics model [5, 6].

Operationally, we fit $|\gamma(B,\theta)|2$ inferred from intensity correlations vs baseline B and orientation θ to a von Kármán turbulence model; the metric candidate is a stationary residual component in θ exhibiting a distinct functional form that persists across atmospheric bins. All candidate signatures will be tested against detector-induced correlations using a shuttered-source null, a dummy load channel, receiver-swapped runs, channel permutation tests, and electrical cross-coupling bounds established via independent timing chains, EMI injection tests, and time-shift/lag-scan nulls (correlating with an unphysical time offset to ensure true physical correlations vanish).

Disambiguating Stationarity: To isolate this signal, FLiDAR strictly disambiguates three forms of stationarity:

1. **Metric Stationarity:** The physical target is static on experimental timescales.
2. **Atmospheric Stationarity:** The intervening air is locally ergodic over the integration window.
3. **Statistical Stationarity:** The resulting g^ (2) baseline estimator remains stable under ensemble averaging, allowing the static metric perturbation to emerge as an anomalous residual.

Biological Precedent: A biological precedent exists for this hybrid strategy in mesopic (twilight) vision. Deep-sea organisms reveal photoreceptors that combine rod-like morphology with cone-like molecular machinery, shifting visual inference away from phase-sensitive mechanisms toward intensity statistics constrained within narrow spectral bands. The organism exploits the statistical structure that remains after coherence fails.

Operational Byproduct: Learned Noise Statistics for LiDAR Filtering Beyond its role as a constraint experiment, FLiDAR naturally produces high-fidelity statistical models of atmospheric, background, and system-induced noise under real operating conditions. These empirically learned noise statistics can be exported as priors, adaptive filters, or training datasets for next-generation operational LiDAR systems. In this sense, FLiDAR functions as a noise-characterization layer that informs what future LiDAR systems should ignore, not merely what they should detect.

V. Feasibility & The Timescale Advantage

A fundamental distinction separates FLiDAR from classical stellar HBT interferometry: the decoupling of optical and statistical timescales. In stellar HBT, the intrinsic optical coherence time τc (~ fs-ps) dictates both the correlation peak width and the arrival of independent states. In FLiDAR, the intrinsic bunching timescale remains set by the optical bandwidth ($\tau c \sim 1/\Delta\nu$). However, the *atmosphere* sets the refresh rate of independent speckle realizations.

These spatial speckle realizations evolve via both intrinsic atmospheric boiling and transverse wind translation (Taylor's frozen flow). The electronics become tractable because the measurement is designed to compute time-lagged cross-correlations to track and regress speckle translation, while integrating spatial statistics over macroscopic windows rather than resolving the intrinsic temporal peak. The advantage is the relocation of the correlation burden from extreme detector bandwidth to extended integration time. The atmosphere acts as a clock governing ensemble diversity.

The theoretical Signal-to-Noise Ratio (SNR) for such an intensity interferometer scales qualitatively with the square root of the integration time and the detector bandwidth, though precise scaling depends critically on operating in a photon-starved versus speckle-noise limited regime [2]. FLiDAR is designed as a Constraint Experiment, operating over long-integration windows (hours to weeks, extendable) to place upper bounds on metric variance.

VI. The Architecture: Single-Emitter FLiDAR

- **Single Emitter, Split Path:** A single high-power, narrow-linewidth laser source split into two parallel emission paths, separated by a baseline B bounded by the target-projected diffractive speckle size ($\sim \lambda L/D_{target}$) and chosen relative to the receiver-plane speckle correlation length (empirically measured) and/or the Fried parameter r_0. The split paths are isolated and monitored for relative intensity noise (RIN) and pointing jitter, which are regressed out or strictly bounded. Laser wavelength and power are selected under Class-1 eye-safety and atmospheric transmission constraints (e.g., 1550 nm high-power eye-safe operation versus 905 nm detector availability), and the photon budget is closed against background, aperture, and allowable irradiance. Budget closure is demonstrated by predicted and measured count rates at each receiver (signal, background, dark counts) staying below detector saturation/dead-time limits while maintaining the expected integration scaling of the correlation estimator within the conditioned atmospheric bins.

- **Target Geometry Control:** A passive target designed to control return geometry. Retroreflector elements incorporate polarization scrambling/depolarization control and avoid periodic lattice effects (aperiodic spacing) to prevent deterministic return structure from dominating the receiver-plane correlation statistics. Retroreflectors are used to maximize link margin for long baselines; the Lambertian target is the robustness control case for statistical validity.

- **Detectors:** SPAD arrays for early-phase characterization, graduating to multiplexed superconducting nanowire single-photon detectors (SNSPDs) when afterpulsing and crosstalk floors dominate the residual budget. To prevent solar-background saturation and dead-time paralysis, the receiver uses a filter stack appropriate to the laser wavelength (narrowband interference + etalon/FBG where applicable), tight receiver FOV control, and time-domain gating / coded modulation (using time-of-flight range gating and/or PRBS/FMCW-style coding appropriate to the chosen wavelength and detector bandwidth) for background rejection and channel isolation (not for primary ranging). Operations prioritize nocturnal and low-albedo conditions for maximum margin.

- **Analysis:** Cross-correlation of intensity fluctuations between Aperture A and Aperture B.

- **Noise Feature Export:** Correlation residuals, background photon statistics, and conditioned atmospheric noise fingerprints are logged in a format suitable for downstream use as adaptive filtering inputs or machine-learning training data for operational LiDAR perception stacks.

VII. Systematics & Controls

To claim a valid bound, we must characterize detector artifacts, timing jitter, and laser RIN.

The Controls:

- **Active Baseline Metrology:** Thermomechanical drift of the chassis over long integrations will smear the spatial coherence measurement. An auxiliary metrology system (e.g., interferometric or precision encoder-based) tracks relative receiver-aperture displacement to the tolerance required for stable binning in B and θ (set by the measured receiver-plane speckle correlation length and the chosen baseline bin width), enabling regression of thermal expansion, wind loading, and slow ground motion. Metrology streams are time-stamped to the same disciplined clock as correlation accumulators to enable synchronous binning and drift regression.

- **Meteorological Control:** A metric residual is operationally defined by a distinct functional form that persists *after*conditioning on atmospheric state (C_n^2 bins, wind speed/direction bins) and applying a von Kármán model fit. Conversely, a null result is strictly defined as the absence of baseline-fixed residuals after conditioning across $\geq N$atmospheric regimes and $\geq M$ independent nights.

- **Azimuth/Elevation Control:** By rotating the experimental baseline geometry, an atmospheric signal will vary dynamically (wind-sheared anisotropy); a metric anomaly will produce a lab-fixed or path-geometry-fixed anisotropy independent of weather.
- **Chromatic Control (The Master Key):** Any metric-induced contribution is expected to be far less chromatic than atmospheric dispersion. Chromatic control requires calibration of instrument chromatic response and scattering/scintillation chromaticity. Only residuals exceeding this calibrated chromatic budget—evaluated *after* strict normalization for the intrinsic λ-dependent scaling of both the Fried parameter $r_0 \propto \lambda^{6/5}$ and target-diffracted speckle size—qualify as discriminatory signatures.

VIII. Related Experimental Programs

FLiDAR sits at the intersection of established fields:

- **Ambient Noise Seismic Interferometry:** Geophysicists map the Earth's stationary tectonic bedrock by cross-correlating chaotic ocean microseisms over long baselines. FLiDAR applies this mathematical architecture to the optical domain. Here, the baseline-dependent mutual coherence function acts as an empirical propagator statistic analogous in spirit to a Green's-function recovery of the path-integrated medium.
- **Stellar Intensity Interferometry:** Pioneering that intensity correlations survive turbulence [2].
- **Atmospheric LiDAR:** Modeling higher-order statistics of turbulence [6].
- **Quantum Illumination:** Entangled states for target detection in noise [7].

IX. Roadmap: The Protocol

- **Phase 1: Edge-Processed Solid-State:** Edge FPGA correlators compute and accumulate the required second-order statistics (selected lag bins / running correlation accumulators / histogrammed residual metrics), storing sufficient statistics rather than raw streams, while characterizing the non-Gaussian "noise tail" of the atmosphere. Stored products include $\langle IA\ IB \rangle$, $\langle IA \rangle$, $\langle IB \rangle$, selected lagged correlations, and atmospheric/housekeeping metadata for conditional binning and regression. In parallel, the system logs conventional range/intensity outputs to enable supervised pairing between operational point clouds and the corresponding noise fingerprints.
- **Dual-Use Output:** Phase-1 sufficient statistics simultaneously support metric-constraint analysis and the derivation of environment-specific noise rejection models applicable to conventional time-of-flight LiDAR.
- **Phase 2: The "Bench" Prototype (HBT):** Table-top Intensity Interferometry targeting a vacuum-sealed retroreflector to validate the pipeline and establish the Shot Noise floor.

- **Phase 3: Quantum FLiDAR (Optional):** Explore receiver-local quantum noise reduction in the detection chain (e.g., squeezing applied within a sealed receiver module to reduce measurement shot-noise), recognizing that externally propagated squeezing is rapidly degraded by atmospheric loss and mode scrambling.

X. Scientific Payoff: Reading the Scriptio Inferior

The Epistemic Boundary and Failure Modes Because extraordinary claims require extraordinary evidence, we must strictly bound what constitutes a detection. FLiDAR cannot definitively prove a metric origin for an observed anomaly; it can only systematically exclude classes of conventional optical, atmospheric, and electronic explanations. Any detected anomaly must be treated as phenomenological unless independently reproduced across wavelength, geometry, and platform. Furthermore, the architecture admits explicit failure modes. If the atmospheric optical path violently violates ergodicity (e.g., via persistent, geography-locked refractive lensing over the integration window), or if irreducible detector cross-talk prevents statistical convergence, the metric constraint fails.

However, the dual-use spine of the experiment ensures that these "failures" are highly informative. A failure to converge due to intractable atmospheric non-stationarity directly yields the precise environmental noise models required to harden next-generation operational LiDAR. Why build a machine to measure noise? Because "noise" is where the laws of physics are negotiated. If FLiDAR works, it proves that the effective optical metric may admit stationary microstructure and the vacuum is a material capable of storing history. If it returns a null result, it constrains the roughness of spacetime to unprecedented precision.

We call it FLiDAR because we are no longer measuring the distance to the wall. We are scraping away the dynamic surface text of the atmosphere to excavate the invisible *scriptio inferior* that stands between us and the wall. We are doing archaeology on the light itself.

References [1] Gordon, W. (1923). "Zur Lichtfortpflanzung nach der Relativitätstheorie." *Annalen der Physik*, 377(22), 421–456. [2] Hanbury Brown, R., & Twiss, R. Q. (1956). "A Test of a New Type of Stellar Interferometer on Sirius." *Nature*, 178, 1046–1048. [3] Aasi, J., et al. (LIGO Scientific Collaboration). (2013). "Enhanced sensitivity of the LIGO gravitational wave detector by using squeezed states of light." *Nature Photonics*, 7(8), 613–619. [4] Sotiriou, T. P., & Zhou, S. Y. (2014). "Black hole hair in generalized scalar-tensor gravity." *Physical Review Letters*, 112(25), 251102. [5] Goodman, J. W. (1985). *Statistical Optics*. John Wiley & Sons. [6] Andrews, L. C., & Phillips, R. L. (2005). *Laser Beam Propagation through Random Media*. SPIE Press. [7] Lloyd, S. (2008). "Enhanced sensitivity of photodetection via quantum illumination." *Science*, 321(5895), 1463–1465.

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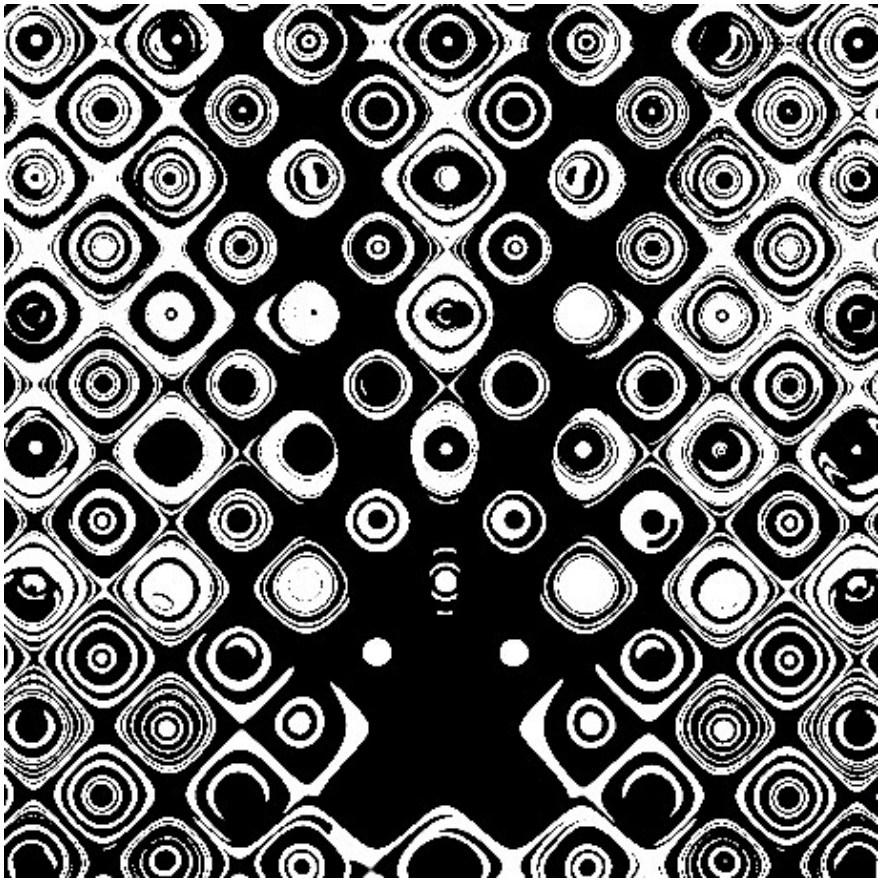
This was written through a collaboration between a human author and AI systems acting as analytical tools. The machines provided structure; the human provided judgment. Nothing appears here that the author did not personally create, refine, choose, and claim.

Hey Josiane,
you light up my life.
Sum Bunny Loves You!!!



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